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Application of the Dynamic Systems Theory to the Elder Population

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ABSTRACT

For this project, the Dynamic Systems theory (DST) of motor performance was applied specifically to the elder population, and set of exercise plans for walking and finger utensil usage were researched and manipulated. The most common individual, environmental, and task constraints seen in elders were designed to create a recommended set of movement plans to help maintain motor performance for each skill. With the average age constantly increasing in the United States, more people are living longer, meaning that people must be able to maintain their motor performance for longer periods of time, to ensure continued mobility.

The set of movement plans was separated into three categories based on the individual, environmental, and task constraints seen in the majority of situations. There are recommendations of how each constraint can be manipulated, so the constraints that apply most to an individual can be used to produce the most efficient movement. This can be beneficial for many elderly people because it can act as their personal mobility plan to improve and enhance motor performance. It can also help benefit younger people as it can be used as a proactive way to transition into a new stage of life. It is hoped that creating these movement plans will give elders more options to enhance their motor performance to maintain mobility. Additionally, by basing the movement plans on the DST, awareness can be raised about its effectiveness, so that more people can understand and apply it to various aspects of their lives.

GOALS

The main goal of this project was to explore the DST and how effective the manipulation of constraints could really be. Of interest were the different ways the various constraints could be purposefully manipulated to affect motor performance outcomes for the elderly population. Many studies explore the theory in child motor development and coaching aspects, but very few apply it to the elderly population. Since people are living longer and the elderly population is drastically increasing, it appeared important to start looking at different options for mobility plans. The theory is based on the present constraints, so applying it to the elderly population seemed perfect since it is at a time where lots of biomechanical changes arise due to the body's compensation.

Another goal for this project was to help bring more awareness and add to the ongoing discussion of the theory. This project focused on the application to the elder population, however the theory can actually be applied to almost anything. It is based on the interaction of present constraints and the different outcomes that automatically occur, due to any changes.

Therefore, it can be used in other applications even outside of exercise science. The intervention was to help spread that awareness and add to the validity of the theory, so more people could start to try and purposefully manipulate their constraints to find the best outcome for them.

METHODS

The mobility plans created were constructed to encompass the three categories of constraints, along with ways to purposefully manipulate them to help improve walking and finger-utensil usage mobility levels. The constraints selected were specifically focused on because research and prior lectures have shown that those were the most common constraints seen in the majority of the elderly population. In addition, the opportunity to observe at a rehabilitation hospital and other private practice facilities, formed the basis of many of the constraints. From those constraints, the components of fitness each represented were derived, and the main ones important for walking and finger-utensil usage were derived to compile a list of suggestive exercises.

The exercise recommendations presented in the mobility plans were selected based on their effectiveness through others' research and modified to fit the specific targeted population. Recommendations with easier modifications were selected, so that they could be done by most people, instead of suggesting bigger transitions that not everyone could manage or afford. The modifications also included different categories of constraints to show individuals that not all three categories have to change to provide a change. All suggestions were then compiled together, with the common constraints selected, to make a list of exercise recommendations people could use to improve or maintain their mobility level, based on their present conditions.

INTRODUCTION OF LITERATURE REVIEW

The dynamic systems theory (DST) is a multidisciplinary, systems-led approach, encompassing many different fields like mathematics, physics, biology, psychology, and chemistry. It has evolved over the years to describe systems that are continuous with time. As an elaboration of the chaos theory, it was derived from mathematics focusing on the behavior of a system that continuously self-organizes, to accommodate any change of condition that put the system into a chaotic state (Hautala & Miyagishima, 2008**)**. "By self-organization we mean the pattern and order of emerge from the interactions of the components of a complex system without explicit instructions, either in the organism itself or from the environment" (Thelen, 2005b, p.259). The self-organization process was concluded from the fact that systems usually display similar patterns, even though there is actually an unlimited range of patterns theoretically possible. Thelen (2005) stated this concept as, "Nothing gives directions, yet the whole system has a order over time (p.260)."

This process of "organized chaos" seemed to be a result of how individual 'open' thermodynamic systems engaged in constant interactions with energy and the environment. Self-organization results in transition between the different states (Davids, Glazier, Araujo & Barlett, 2003). The theory provided a base for others to build upon, stating that all dynamic systems are highly sensitive to initial conditions. Small changes in those initial conditions will result in a chain of events that will lead to a larger effect later on. A more known version of this is the Butterfly Effect mentioned by

Edward Lorenz (2015) in his research paper about how a butterfly flapping its wings in Brazil can cause a tornado in Texas.

Overtime, the theory moved from different branches in science and Nikolai Bernstein proposed the degrees of freedom (DOF) problem (Davids, K., Glazier, P., Araujo, D., & Bartlett, R., 2003). The DOF problem states that when using a constraints-led approach, the minimum number of DOF required for a specific motor task will always be forced to emerge, due to the body always working to be efficient and trying to get a result using the least amount of effort. The human body has almost an infinite amount of DOF based on the muscles, joints, and kinematics that all work together to have different movement patterns for the same goals. The nervous system basically "picks" from the various degrees of freedom available to find the best performance pathway for that specific situation and its interaction with the environment. With so many options available and so many different combinations based on the various constraints and environments, it is difficult for the body to easily pick just one. So, Bernstein concluded that there has to be some type of self-organization process going on that provides the fewest number of DOF available to narrow down the best performance outcome.

Building on Bernstein's approach, Karl Newell proposed a modified version of the theory called the Model of Constraints (Davids et al., 2003). His version split constraints into three different categories: individual, environmental, and task. He stated that these three categories of constraints constantly interact to produce a movement outcome. Constraints were defined as boundaries or features that interact to limit the

amount of organization possible, resulting in fewer configurations available for that system, so that the single best one can emerge. Individual constraints consist of structural and functional components. Structural components include more physical aspects like body height, weight, and composition, while functional components are characteristics like motivation, attitude, and psychological state. Environmental constraints include characteristics like socioeconomic status, weather, and living surroundings. Task constraints include equipment being used, rules, or expectations of the task.

Like Bernstein, Newell proposed that the interaction of constraints forces the system to provide the most efficient motor performance outcome. However, he went back to the chaos theory and added that if any of the present constraints were to change, even in the slightest, the system is put back into a chaotic state. Once in a chaotic state, the dynamic system will automatically reorganize itself to find the most efficient solution for that system to produce the best movement outcome for that system to be back in a stable state. This process constantly repeats as present constraints constantly change, and the system tries to go back into a stable state.

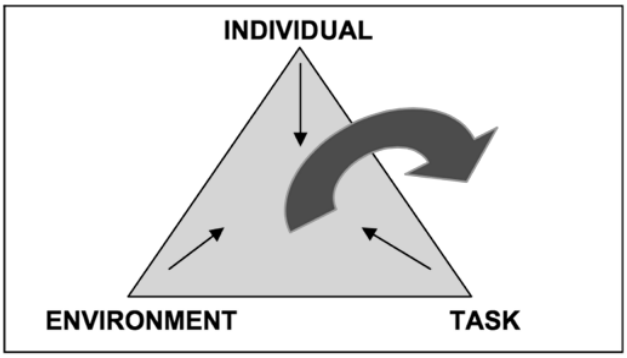


Figure 1: Dynamic Systems Theory Model

(Hautala & Miyagishima, 2008)

The theory has been used to explore the possibility of whether or not constraints could be purposefully changed to cause a system to reorganize. A new and more efficient outcome for that system would be produced, and although some changes might have a more predictable outcome, people started to question if less obvious outcomes could be created based on the theory. Newell stated that even the slightest change will throw the dynamic system into chaos and make it automatically reorganize itself to produce the most efficient outcome. Therefore, the idea of purposefully manipulating constraints to dictate motor performance was explored by many for childhood development, adapted physical activity, coaching, and motor learning applications.

In motor performance fields, the application of the dynamic systems theory based on Newell's constraints led-approach is mostly seen in coaching areas. Usually, the task and environmental constraints are changed to produce a more desired outcome. In the journal article, "Applications of Dynamical Systems Theory to Football" (Soccer to us Americans) the authors tried to enhance controlled ball skills in children (Davids, Araujo, & Shuttleworth, 2003). They had novice leveled children practice juggling and dribbling, but experimented with different ball sizes and weight. Two groups practiced with two different ball sizes and weights, and a control group practiced with the ball size and weight recommended for their age group.

The authors discussed how each group looked slightly different while dribbling and juggling the ball, due to the different ball sizes. All children were asked to do the

same tasks in both the pre and post-tests, but biomechanically looked different across the three groups. The results showed that the group practicing with a smaller and heavier ball performed more successfully on the post tests, even though the recommended ball for their age was not used. All groups significantly improved their skills from the pre-test, however the group practicing with a smaller ball performed the best. The authors concluded that by using different sized balls, the dynamic system is forced to automatically reorganize itself, which can help with the learning stage to produce a more efficient movement later on (Davids, Araujo, & Shuttleworth, 2003).

Similar to the idea that variations in technique can still produce the same outcome for optimal performance, Glazier and Davids (2012) discussed the misconception many people have of how there is only one perfect technique for every specific skill in sports. They discussed the different individual, environmental, and task constraints each performer would have, and how the interactions of them would cause variations in each technique used for the same goal. For their study they specifically looked at golf swing techniques since most people believe that to do well in golf, individuals must have the perfect golf swing. They concluded that it actually does not exist because “the confluence of constraints impinging on performance is patently individual-specific and fluctuates continuously over time” (Glazier & Davids, 2012, p. 2). That there will be variations of movement patterns across different golfers as each individual has to account for their specific differing constraints and find the best solution for them.

In a later study, Glazier et al. (2003) showed this concept at work. They analyzed postural control and stability in individuals with Anterior Cruciate Ligament (ACL) deficiencies by changing task constraints. Their results showed that individuals with ACL deficiencies had smaller center of pressure (COP) measurements compared to people without ACL deficiencies. According to previous research though, smaller COP measurements are indications of low postural control, however they concluded that the ACL deficiency group actually had good stability. So, even though there was a difference in COP measurements, they still saw similar stability levels for both groups. They concluded that this discrepancy must be due to the different constraints interacting to find the most stable solution. The authors also looked back to Bernstein's DOF problem and how using the constraints-led approach forces the minimum number of DOF required to emerge.

On the other hand, some people have proposed that there is not yet enough validity to the dynamic systems theory based on Newell's model of constraints. Paul Fusella (2013) explored different views of the theory through the application of cognitive science. One main argument that was brought up was that the theory is too broad for the complex mind. That there is so much complexity in the real world, the theory's broad definition does not seem to encompass everything. The self-organization part of the definition also proposed some suspicions because it is known that sometimes "systems exist where in no appropriate configuration of constraints exists, be it modular, central-executive, or self-organized, and that could be determined in the right amount of time" (p. 9).

Therefore, Fusella (2013) argued that for the theory to have more validity, it needs to account for self-organization and brain-and-body configurations for tasks in an experimental paradigm and conceptual model. It needs to challenge the alternative viewpoints and incorporate into view what is accurate and relevant about those traditional views in cognitive psychology. He stated that there is so much suspicion of the theory because of how promising its approach seems to be, but how new it is in cognitive science.

Although his claims and suspicions are valid arguments, other researchers have argued in favor of the connection between DST and cognitive science. In 2005a, Ester Thelen stated how applicable the theory is to childhood development. She stated that the constraints-based theory can be seen in babies that have physical abnormalities, but can still crawl and walk successfully. She also noted that babies are not programmed to walk and talk at a certain age, yet the majority of them do. She explained this as the interaction of constraints forcing the new systems to automatically reorganize to a more stable state, especially at a time that the individual constraints are changing the most. That infants can not necessarily think, so their actions must be coming from an automatic process.

However, like Fusella, Thelen (2005a) did mention that further research needs to be done and that the application of the theory in cognitive science in still new. Nonetheless, 15 years have passed since she published her article and five years have passed since Fusella published his. Since then, there have been many more studies showing the DST at work. It has been applied successfully to so many kinesthetic and

development applications that the theory has advanced and the validity of it increased. Fusella even mentioned in his paper at the time that even though the theory is still new, the successful work already done on it is too much to ignore.

LITERATURE REVIEW

Elderly Population

Despite the fact that there are various studies conducted on the application of the DST in coaching and childhood development that have supported the theory, there are very few existing studies that address the application in elders. According to the World Health Organization (WHO), 65 years old is the official age as the definition of "elderly" or older person (2017). Recently, there has been an increase in the elderly population with an estimated 50 million senior citizens as of 2016 ("The Aging of the United States Population", 2017). This can be seen with a population pyramid, which is a graphical illustration that shows a distribution of various age groups in a specific population. It is typically used to monitor the projected increase or decrease of a population since it shows the breakdown of all ages that can be used to make predictions off of. An ideal pyramid would show a majority of the population to fall under the ages of a "working class", with less elderly and children to ensure more stability for the future.

However as of 2016, the population pyramid for the United States showed not only that there are more people living longer, but that there is a huge predicted age shift that will come in the next 20 years due to the increase in the population currently

under age 65. The Baby Boomer generation will soon enter their elderly years, which will increase the overall amount of elderly people more than ever before. The highest increase in the elderly population is predicted to occur between 2010 and 2030 as the baby boomers enter age 65 and up and help grow the elderly population by an average of 2.8 percent annually (Mather, 2016).

Ideal Population Pyramid

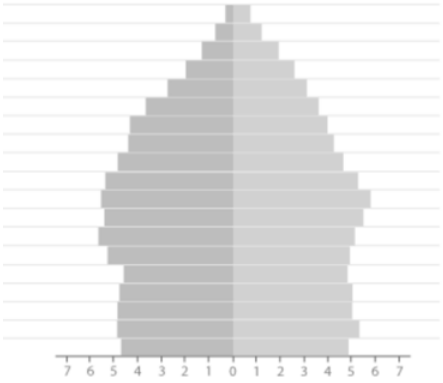


Figure 2: Ideal Population Pyramid

(Data Visualization Catalogue, 2019)

Population Pyramid of the U.S.

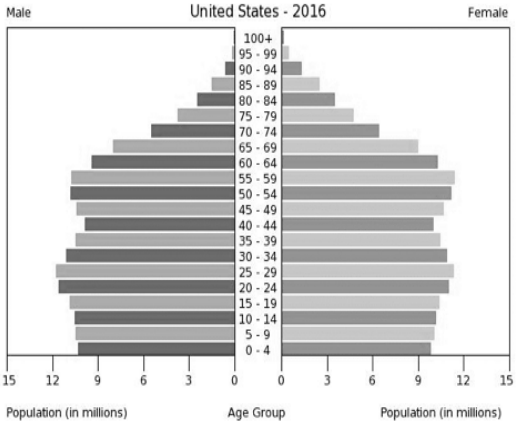


Figure 3: 2016 U.S. Population Pyramid

(CIA World Factbook, 2017)

According to the U.S. Census Bureau Statistic Brief (2018), the number of persons in the United States under the age of 65 has tripled during the 20th century. Simultaneously, the number of people aged 65 or over has jumped by a factor of 11. It is estimated that by 2030, all the baby boomers will be older than age 65, expanding the elderly part of the population so that one in five people will be at least 65 years old or

above. It is also predicted that in 2030, there will be approximately 78 million people who are 65 years and older, and 76.7 million people under the age of 18 (U.S. Census Bureau Statistic Brief, 2018).

This means, that for the first time ever, the number of elders will be greater than the number of children in the United States. This is important because society is going to have to address this issue sooner or later. More people are living longer and entering age 65 and above, with the average life expectancy now increased to 78.7 years. However, there are fewer people being born and entering the working-class, which does not help replace the amount of people hitting retirement. By 2020 it is estimated that there will only be three-and-a half-working-age adults for every retirement-age person. By 2060, that ratio will decrease to two-and-a-half working-age adults for every person over the age of 65 (U.S. Census Bureau Statistic Brief, 2018).

Not only is this important because of how it could affect our economy and the way society functions, but there will also be a need to help elders maintain their mobility. There will need to be much more research and work done to be able to provide more options than what is currently available to this population. Since the biggest population shift is predicted to be in the next 20 years, the work needs to start now in anticipation for the overwhelming increase later on (U.S. Census Bureau Statistic Brief, 2018). The longer the delay in finding more solutions; the more difficulty the United States may have when that population shift finally occurs.

General Biological Impacts of Aging

One major concern within the elderly population is the maintenance of mobility. The definition of mobility is the ability to move freely, so that people can do what they need to do throughout the day. However, as people age, it is only natural for mobility to decrease with less physical activity and the degeneration of the physical body. Burr (1997) reported that bone mass irreversibly starts to decline once an individual reaches the age of 40 years old. Bone usually remodels due to the stresses placed upon it, so more mass is typically built on the areas that are used more. The thicker the bone develops, the more it can compensate for loss later in life, which is why it is important to start building peak bone mass, through regular exercise, before the age of 40. Once 40 years of age is reached, bone mass will automatically start to decline, and as well, the amount of physical activity typically lessens, which decreases the amount of stress put on the bones even more. This causes the osteoblasts (bone cells) to produce much less than before, ultimately thinning the bones and making them easier to break.

This decrease in bone thickness that comes with age and lifestyle changes can affect posture and strength, which also decreases overall mobility. This can be seen in specific disorders like osteoporosis, which is a medical condition in which the bones become brittle from the loss of tissue (Mayo Clinic, 2018). According to the National Osteoporosis Foundation (2018), 80% of all estimated cases are women, and approximately one in two women over the age of 50 will break a bone because of osteoporosis. Women have an increased risk of developing osteoporosis, compared to men, because of their smaller natural bone structure. Menopause also decreases the

amount of estrogen produced, which can cause a loss in bone, as well. Adversely, men typically tend to have higher peak bone masses, due to larger widths and size from accumulations of skeletal mass. This means that men typically have more bone mass before the age of 40, which is why they are able to better compensate for the natural bone loss that accompanies age, compared to female counterparts. Overall, these biological changes decrease the density of bones, potentially causing a decline in physical activity participation and mobility for some individuals.

Along with bone thickness starting to decline at 40 years old, Burr (1997) also suggested that muscle strength declines (sarcopenia), as well. Between the age of 50 to 80 years old, people may lose a large proportion of muscle mass, losing about 50%-60% of muscle. It was also reported that people who are physically inactive can lose as much as 3%-5% of muscle mass each decade after 30 years old (Armstrong, 2018). This muscle atrophy that occurs as we age can lead to a reduction in muscle strength and endurance, which is seen to decrease basal metabolic rate and aerobic capacity. A decline in aerobic capacity can lead to more reductions in physical activity levels and how much physical activity an individual can tolerate (Rikli, 2005). This decreases the amount of physical activity an individual participates in and even increases the amount of body fat over time, especially when people do not adjust their caloric intake to their reduced energy expenditure. This leads to an increase in weight gain and obesity, which decreases mobility levels and puts an individual more at risk for developing other chronic diseases that can cause disabilities.

Rikli (2005), however, also contended that muscle atrophy can be reversed, to a certain extent, with exercise and improved nutrition. In her study, she reported that strength training, specifically progressive resistance exercises, is one of the most important types of exercise for older people. Strength training not only helps build muscle mass and strength, but increases aerobic endurance, flexibility, dynamic balance, self-confidence, and self-esteem. The self-confidence and self-esteem aspects are especially important for elders who have previously slipped or fallen and are apprehensive about it happening again. These factors all improve functional abilities, like walking and stair-climbing, or using the upper body muscles to stand and feed oneself. This is why regular physical activity is important for elders to be able to maintain mobility levels and why there is a need for more exercise program options. The Baby boomers will soon start to become elders and the population will start to shift.

In addition to bone and muscle loss, a common condition that elders develop is osteoarthritis. This condition affects millions of people worldwide and occurs when the cartilage between the ends of bones degenerates and causes pain when moving the joints. It is most common in the hips, knees, lower back, neck, and small joints in the fingers since those joints tend to be used the most (Arthritis Foundation, 2018). Rikli (2005) had mentioned in her study that progressive resistance exercises are just as effective for people with arthritis as it is for trying to rebuild muscle mass. The degeneration of cartilage is an irreversible process, with the exception of getting replacement surgeries, and as the joints become stiffer, individuals tolerate less

movement. Their willingness to maintain regular exercise declines, as the arthritis keeps progressing, slowly decreasing their mobility.

Connection to Walking (Gross Motor Skill)

The decrease in bone density, muscle mass, and cartilage impacts an individual's ability and willingness to walk as they age. The changes in bone thickness, muscle atrophy, and cartilage degeneration all affect one another as the body tries to compensate. The National Library of Medicine reported that usually walking gait becomes slower, shorter, and more unsteady as people age, due to mobility and balance loss. Posture is impacted from the loss of muscle and bone mass, which causes the intervertebral discs to lose flexibility and allow the spine to curve forward.

As a result, the spine is compressed, and more strain is put onto the supporting muscles and ligaments during movement and weight-bearing activities. This not only leads to pain and fatigue but decreases the ability to maintain balance and coordination. Poor posture can alter an individual's base of support when standing, putting them in an unbalanced state before even taking the first step to walk. In addition, poor posture can alter an individual's step width and height, decreasing balance and coordination, making it more difficult to walk. This is why elders have a difficult time performing gross motor skills, like walking, because of how much balance, coordination, and agility it requires at a time where bone, muscle, and cartilage is slowly degenerating.

Similarly, Ehsani, Abdollahi, Bandpei, Zahiri & Jaberzadeh (2015) also reported that older adults need to learn or relearn motor skills due to the impacts of aging. The

body compensates so much for individuals to still be able to do certain tasks, however many of the motor skills that play an important role in functional abilities must be relearned. Ehsani et al. (2015) reported that there are significant differences in learning between older and younger individuals. Younger adults tend to learn more while doing the activity and in the retention stage, once the task is completed, compared to older adults where most of the learning is seen while doing the activity. The main difference between the two age groups is that older adults are not able to retain what they learned once the movement is over, due to changes in synaptic efficiency that comes with age. This causes slower performance and difficulty when doing functional tasks, like walking, because of the constant relearning that must take place each time. Plus, the environmental conditions are never going to be the same, so even more relearning must take place, which causes slower processing and performance outcomes since elders have a harder time with retention.

Another problem that impacts walking and mobility, for elders, is the fear of falling. Not only is balance, coordination, vision loss, and muscle all degenerating, and increasing the risk of falling, but the development of other chronic conditions can increase the risk, as well. According to the National Council on Aging (2018), approximately 80% of older adults have at least one chronic disease, while 77% have at least two. These chronic diseases, like Type 2 Diabetes and Heart Disease, can cause dizziness and fatigue that can help increase an elder's risk for falling. It is also reported that an older adult is treated in the emergency room for a fall every 11 seconds, and dies from a fall almost every 19 minutes (National Council on Aging, 2018). These

statistics show just how frequent older adults fall, and how dangerous falls can be to this specific part of the population.

Falls can result in broken bones, bruises, and pain, which takes longer to heal compared to younger bones. Sometimes, the bones might not even heal completely because of the constant loss of bone that occurs with age. The amount of bone being loss is just more than the amount of bone that is being remade, so it never completely gets a chance to heal. This can leave individuals with need for canes, walkers, or wheelchairs for an extended period of time, or even permanently, which will limit their ability or willingness to walk. Even if an elder fell, and did not experience any serious injuries, they still might be nervous or fearful that it will happen again.

Deshpande et al.'s (2009) study found that the fear of falling increased with age, showing more women fearing it compared to men. More than half of the individuals in their study reported the fear of falling, while 70% of those people had not even fallen the previous year. Individuals who did not, personally, feel adequate enough with their standing balance ability, lower limb strength, and visual contrast sensitivity all restricted their activity because of the fear they would fall. Deshpande et al. (2009) concluded that elders who decided to restrict their activity levels, do so based on a combination of poor psychological, physical, and sensory function.

Therefore, it is not just physical aspects that can prevent elders from maintaining mobility and their willingness to walk. Deshpande et al, (2009) mentioned that an individual's decision to restrict physical activity levels is based on their personal perception of how well they mastered those specific skills. So, if an elder were to fall,

they might not feel as confident in themselves anymore. Even if the fall did not result in any serious injuries, and they were physically fit, their psychological state can still be affected. This would cause them to want to walk less from the fear that it might happen again, leading to a loss of mobility because of the limited physical activity they would be getting.

Connection to Finger-Utensil Usage (Fine Motor Skill)

In addition to cartilage degenerating at the hips and knees, another common site is in the hands and fingers. The hands and wrist have multiple joints that are exposed to wear, overtime, as one ages. Similar to knee and hip arthritis, this exposure of bone at the joints can cause a lot of pain that make the activities of daily living difficult to endure. Activities like sewing, writing, gardening, washing dishes, and using utensils to eat can all become more difficult as the pain and inflammation increase. The main difference with finger arthritis, compared to the hip and knee, is that the surgery to repair the damage is rarely used as treatment (American Academy of Orthopaedic Surgeons, 2018). More than 600,000 knee replacements are performed each year; however, arthritis hand surgery has a high complication and failure rate.

The two main surgery options available are arthrodesis and arthroplasty (Arthritis Foundation, 2018). For arthrodesis, the bones of the joint are fused together to create a stronger and more pain-free knuckle. Little flexibility or movement remains, but the joint is more stable than before. For an arthroplasty surgery, the damaged joint is replaced with an artificial implant to relieve pain and restore shape and function.

Both surgeries are not frequently used as treatment, except for really drastic cases, because the results are less satisfactory than hip and knee replacements. The hinged finger implants cannot replicate normal finger mobility and the silicone rubber used can break or slip easily. This leaves the only other treatment options available to include anti-inflammatory medications, joint supplements, cortisone injections, hand/occupational therapy, ice and heat treatment, and splints. None of these, cure the arthritis, but are there to help manage pain and mobility.

As the osteoarthritis in the hand and fingers progress, the bones that make up the joints can lose their shape, causing more pain to occur. This not only makes an individual less likely to perform activities that would evoke the pain, but limits the range of motion and makes it more difficult to do certain skills, like using utensils to eat. Fine motor skills, like finger-utensil usage, use the coordination of smaller muscles to help perform smaller movements. It requires more focused precision and manipulation, compared to gross motor skills, like walking, that rely more on balance and agility.

When the joints in the fingers are impacted from arthritis, they become stiffer and function is impaired. Grasping, reaching, carrying, release, and hand manipulation are all affected, making it more difficult for an individual to use a utensil to pick up the food, bring it to their mouth, and place it back down to continue eating. Carmeli, Patish & Coleman (2003) reported that there is a 60% decline in grip strength after 60 years of age. The substantial loss of muscle fibers and length reduces stabilization and grip strength. This impacts the ability to grasp and hold utensils up, with enough strength and precision, to successfully control and feed oneself for the duration of a full meal.

Carmeli, Patish & Coleman (2003) also discussed how changes in sensory perception in areas like the hand are normally seen as people age. It is frequently overlooked in comparison to when sensory changes impact areas like the knee joint because the effects are not as drastic and noticeable in the beginning. However, there has been a decline seen, in many studies, with tactile sensation that contributes to the overall processing of afferent information associated with hand and finger movements. Fingertip force responses are impacted, as well, which can lead to deteriorating automatic responses and reaction times. Since accurate sensory input is essential for well-controlled precision and the manipulation of smaller movements, the ability to complete fine motor skills, like finger-utensil usage, is decreased as people age. The refined coordination of forces, exerted on the utensils by the tips of the fingers and thumbs, are not as mobile as before, which causes elderly to have difficulties with independent feeding.

Vision is another thing that impacts sensory input and visual feedback. Age-related vision loss is normal as people get older, usually resulting in people needing corrective lenses. In individuals 60 years and above, loss of slight, beyond the normal age-related vision deficit, increases, and other permanent disorders can occur. Normally, intact retinal image motion is impaired, which affects an individual's visual perceptual skills, like hand-eye coordination and depth perception. This includes the ability to organize and interpret the information from the eyes, process it, and give it meaning to carry out the rest of the sequencing steps needed.

In order for an individual to be able to independently feed oneself, the eyes have to be able to process where the food is, in relation to the hands, and then tell the hands how much pressure to place on the utensil to be able to get food on it and bring it to the mouth. Hand-eye coordination is something that majority of the population takes for granted, automatically carrying out the actions without even thinking twice about how the food is getting into the mouth. However, when eye tracking and perceptual skills are impaired, the task becomes more difficult, and the sequencing of events that used to automatically occur, does not happen as smoothly. This impairs the ability for elders to use utensils when eating and their ability to carry out many other gross motor skills that require eye tracking and hand-eye coordination. This, in combination with any arthritis, muscle loss, bone degeneration, and changes in sensory perception that one could experience, can decrease the willingness to participate in activities that require gross motor skills, which would not help with the maintenance of hand/finger mobility.

The next page with have a list of common constraints for walking and finger utensil usage.

Common Constraints for Walking

Individual Structural Constraints:

- Bone mass automatically starts to decrease once beginning at 40 years old
    - Decrease in physical activity, decreases the amount of stress put on the bones, causing the thinning of bones
    - Osteoporosis- condition where bones become brittle from loss of tissue
        - Women have an increased risk of developing
- Degeneration of Cartilage
    - Can lead to osteoarthritis
    - Causes pain when moving the joints
    - Most common in the hips, knees, lower back, neck, and small joints
    - Irreversible process
- Muscle Atrophy
    - Muscle mass decreases
        - People who are physically inactive can lose as much as 3%-5% of muscle mass each decade after 30 years old
        - People lose most of muscle mass between the ages of 50 to 80 years old, losing as much as 50%-60%
    - Leads to a decrease in strength
    - Decrease in muscle endurance
    - Decreased range of motion and flexibility
    - Can be reversed to certain extent with exercise and improved nutrition
- Decrease in Balance
    - Poor posture can alter individual's step width and height
    - Less coordination
    - A decline in vision can make it harder to walk
- Pain Tolerance
- Development of Chronic Diseases

Individual Functional Constraints:

- Learning styles
    - Functional abilities must be relearned due to the impacts of aging
    - Younger adults tend to learn more while doing the activity and in a retention stage
    - Older adults do most of the learning while doing the activity

    - Older adults are not as able to retain what they learned once it is over, causing slower performance
- Confidence Levels
    - Some might be nervous or scared of falling
    - If they have already fallen, they might not have much confidence, preventing them from walking
- Self-esteem
    - Low self-esteem can lead people to be unwilling to walk often
    - Low levels of self confidence can cause an individual to restrict physical activity levels
- Motivation/Attitude
- Prevention Awareness

<u>Environmental Constraints:</u>

- Finances/ Socioeconomic status
- Transportation/Availability
    - Accessibility to physical fitness activities
    - access to necessities
- Home layout
- Type of flooring versus carpet
- Everyday routine
- Social support
- Occupation
- Access to treatment, if needed

<u>Task Constraints:</u>

- Walking Devices
    - walker, canes, wheelchairs, walking sticks
- Supportive braces used/available
    - Type of footwear used/ available
- What they were told to do by professionals/those supporting them

Common Constraints for Finger-Utensil Usage

Individual Structural Constraints:

- Cartilage Degeneration
    - Finger/wrist arthritis
    - Joints lose shape, causing pain
    - Limits range of motion and coordination of the fingers
- Limited Range of Motion
    - Fingers become stiffer and function is impaired
- Grip Strength
    - 60% decline in grip strength after 60 years of age
    - Reduces stabilization, affects ability to grasp and hold
    - Precision impacted
- Sensory Perception
    - Tactile sensibility decreases
    - Force responses are impacted
    - Perceptual skills impaired
- Decreased automatic response and reaction times
    - Decreased hand-eye coordination
    - Vision loss and eye tracking skills
- Pain Tolerance
- Development of chronic diseases

Individual Functional Constraints:

- Learning styles
    - Same as walking
- Motivation/Attitude
- Willingness
- Interests
- Prevention Awareness

Environmental Constraints:

- Socioeconomic Status
- Everyday routine
- Social Support
- Home layout

- Occupation
- Access to treatment, if needed

Task Constraints:

- Utensils used: normal or adaptive silverware
- Supportive braces available
- What they have been told to do by professionals/those supporting them

External Focus of Attention

A new growing body of research is consistently showing how effective it is to use external focus of attention, when providing instructions and feedback for individuals to respond to. External focus of attention is when the instruction and feedback is worded in a way that forces the individual to direct their attention to the desired outcomes of movements and the external cues, rather than the movement itself (internal focus of attention). For example, external focus of attention-based instruction would be telling someone to "step up onto the marker on the block when instructing someone to do step-ups." For the same task, internal focus of attention instruction would use more phrases like, "move your hips to the right and straighten your knee before stepping" (Johnson, Burridge & Demai, 2013, p.961). The internal focus of attention directs more of the attention to the kinematic features of joint actions and body-position relationships, while external focus of attention focuses on the goal and function of the movement, emphasizing constraints external to the body.

Gabriel Wulf (2007) reported that using internal focus of attention is equivalent to giving no instruction or feedback at all when it comes to improving an individual's performance. Her study showed how internal focus can cause an individual to put too much attention and concentration into the movement itself, which ends up decreasing performance, instead of enhancing it. On the other hand, external focus of attention makes an individual more focused on the outcomes, which allows for improved performance as the individual's actions are more automatic and less controlled. She stated, "adopting an external focus reduces conscious interference in the processes that

control our movements and, as a consequence, results in enhanced performance and learning (Wulf, 2007, p. 113). It is almost as if the desired outcomes are achieved as a by-product when there is less conscious control.

This type of feedback was seen to be especially advantageous as tasks became more complex and challenging because the responses were less restrained. Wulf's studies showed how even just changing one word can make an individual immediately fix themselves to increase performance, if that one word shifts the focus from internal to external. For example, keeping the hand still versus keeping the cup still showed major differences when trying to carry a cup of coffee. It was also mentioned though that sometimes it is beneficial to use a mix of internal and external focus-based instruction when first learning a new task. This mix of both would include phrases like, "lift your toes up and step onto the block" (Johnson, Burridge & Demai, 2013, p.961). However, Wulf still concluded that it is beneficial to transition to all externally focused based instruction, once the task is familiar to the individual, for the best results.

On the flip side, it has been proposed by many researchers, like Masters and colleagues (Masters RSW, 1992), that people who have to relearn new tasks, need more internal focus of attention, even though the task might be something similar. For example, Masters and colleagues proposed that people who suffer from a stroke, and have to relearn how to walk, need more internal focus-based instruction because they are re-learning a task that might have a different way of occurring than before (Masters RSW, 1992).

However, consistent to Wulf's research on external focus with stroke patients, Johnson, Burridge & Demai (2013) also reported how using external focus of attention can be more beneficial for people who have suffered a stroke. The authors reported that internal focus of attention actually makes it more difficult for post-stroke patients to perform tasks because it increases self-consciousness, slows information processing, and reduces attentional capacity, in a population that is already experiencing those things due to suffering from a stroke. This makes movement control more conscious, which reduces automaticity, and hinders learning and retention capacity to produce less desired movement outcomes.

In addition, Wulf (2007) did studies with external focus-based instruction in special populations. These populations included children, individuals with Parkinson's Disease, stroke patients, speech disorders, and elders. In all studies, it was consistent that external focus of attention enhanced movement performance outcomes. Her specific study with the aging population focused on the ability to track an object. She focused on hand-eye coordination and reaction time since it is required in many activities of daily living and usually decreases with age. The goal was to know "whether instructing older individuals to adopt an external focus could enhance their performance on a task that required coordination of visual information and hand movements" (Wulf, 2007, p. 174). The results showed faster reaction times and that as the difficulty increased, performance was better when external focus was used. She concluded that adopting external focus can be effective even for the elderly population, especially

when performing familiar tasks that has become more of a challenge due to the effects of aging.

This big theme of automaticity relates back to the DST because it emphasizes the motor system being able to naturally self-organize with external focus. When external focus of attention is used, the phrase and task is being changed. Since external focus directs the performer's concentration to specific performance outcomes, the goal of the task is essentially different than when internal focus of attention is used. Instead of focusing on your arm position and your release of the ball when the arm is extended, the task would be to just focus on the flight of the ball. This causes the interaction of constraints to change and the system to automatically reorganize itself, causing different movements to emerge.

When using internal focus of attention, there is just too much focus directed on the specific movement and kinematics that forces people to think too much on the wrong thing. People end up limiting themselves and regulating their own movements, sometimes without even knowing they are doing so. This results in less effective desired outcomes and provides less learning for that individual (Johnson, Burridge & Demai, 2013). Although there is little research done on external focus of attention specifically related to the DST, this change in focus could be represented as the interactions of constraints, which would logically the way individuals think and carry out movements.

Therefore, for the best performance outcomes, mobility plans could be written and constructed in a way that shifts individual's focus to external cues. The feedback

presented in the mobility plans for both walking and finger-utensil usage were specifically constructed to direct an individual to focus on the external cues. There are some internal focus-based instructions used to explain the exercises further since this was all written without reference to any specific situation, but it could be changed to external focus in the right scenario. Or a combination of both could be used if an exercise is considered a new skill that the individual has to learn. Since walking and finger-utensil usage are usually considered a skill that the majority are already familiar with, more externally focused feedback should lead to better performance outcomes. The consistency shown in studies observing external focus of attention within special populations, supports its more accessibility to our diverse population.

EXISTING PROGRAMS

Existing Programs for Walking

Currently, there are many options available to elders that are designed to help maintain mobility and strength for walking and finger-utensil usage. Programs like Zumba, water aerobics, yoga, tai chi, and individualized health and wellness programs are just some examples that most communities offer to elders, outside of physical and occupational therapy. These programs focus on muscle strengthening, flexibility, endurance, and balance, which all helps individuals have less of a sedentary lifestyle. Most programs normally focus more on maintaining skills required for walking,

compared to the skills required for finger-utensil usage, however there are some parts within the programs that can help benefit both.

For example, water aerobics is especially beneficial for elders with arthritis pain particularly in the lower body, because the buoyancy of the water puts less stress on the joints. This leads to less pain and allows individuals to be able to exercise, build up strength from the resistance of the water, and help maintain mobility, in a more comfortable way compared to if on land. These seem like they mostly help with the maintenance of walking, though some water aerobics use pool noodles or other equipment that require individuals to use hands and fingers. This can help improve grip strength and upper body strength, which would have an impact in the ability for an individual to feed oneself. Every program is different though, so there are different skills emphasized.

Although these programs are beneficial and are designed to help maintain mobility, they are not specifically connected to the DST. There are actually very few exercise programs existing that are designed by specifically incorporating the theory. Constraints under the three different categories (individual, environmental, and task) can be identified from each program and can be considered in applying the DST since almost any small change would cause the interaction of constraints to change for a different response.

For example, one environmental constraint for water aerobics would be the pool. That change alone, compared to doing the exercise program on land, can help elders have an easier time gaining muscle mass to help maintain their ability to walk. However, the programs were not specifically designed with the intention to use the DST and manipulate the constraints for the best outcome for the elderly population. The theory can be applied to the program, but it was not the program's intention to specifically apply the theory and maximize the amount of constraints that could be manipulated to help find the best movements for the majority of the elderly population.

Equally as important, the costs and availability of these programs should be considered along with transportation and other environmental constraints. Not every area will offer water aerobics in their community, and many elders might not have access to a pool or body of water that they can exercise in. Not every elder might be able to afford the cost of these programs, and many might not have the transportation to get there. Even though this situation can be related to almost all programs, since a pool or body of water is needed for this specific program, it can make it a little more difficult for areas to provide. So, although water aerobics can be a very beneficial option that helps individuals, especially elders, be able to exercise with less pain to help maintain mobility, there are other important constraints that could prevent more people from participating. This is why it may be more beneficial to design programs

specifically around the DST, so that more constraints can be considered and accounted for, so that these exercises can be more accessible to the specific population.

In addition to exercise programs that help with the maintenance of mobility for walking, there is a range of home adaptations and adaptive equipment available. Walkers, crutches, walking sticks, single-point canes, quad canes, knee walkers, and gait trainers are all different types of equipment that help provide extra support. This can alleviate pain, provide more stability, remove weight from the extremities, and offer extra balance to all help an individual be more mobile. Crutches are not normally used by the elderly though because it requires more upper body strength that often may be limited in some elders. These items can range in price, with walking canes being the most affordable. However, if the equipment is not tailored to an individual's specific height and need, then it is not as beneficial and could even cause other problems, such as back pain, due to the body's natural way of compensating.

There are also more home adaptations now being offered to help elders have an easier time maintaining mobility in their home. These adaptations include changing carpet to flooring, widening doorways, redesigning floor layouts, adding rails, creating half steps, installing ramps, and adding more assistive devices ("Paying for Senior Care", 2019). These options all help accommodate any equipment that may be used to help maintain the ability to walk and enables an individual to age in their home for long-

term. It helps assist individual needs and can help prevent falls or any accidents that could normally occur.

Most states currently offer Medicaid programs to cover home modifications to enable elderly individuals to remain living at home. These programs are considered Medicaid Waivers, and vary by state, but offer financial aid for assistive technologies and physical home modifications. The requirements also vary by state, but usually require that the individual needs the level of care provided in a nursing home, intermediate care facility or require assistance to manage their activities of daily living. Financially, applicants are limited to around $2,250 per month in income for the 2018 year ("Paying for Senior Care", 2019).

Although it is great that there are programs existing to help financially support home modifications, these waivers typically have limited enrollments and long waiting lists. There are many people who will not be eligible or granted the waiver, and these home modifications can be, financially, out of reach or not considered an option because of that. There are some home adaptations that might be more affordable than others, but it is not the optimal and most accessible solution. Changing floor layouts to clear hallways and moving furniture around to ensure widened spaces for canes or walkers to fit, is one option that will not be a financial burden, but there is only so much it can provide for increased mobility.

Existing Programs for Finger-Utensil Usage

Unlike the various programs offered to maintain bigger muscle groups for gross motor skills, there are not a lot of programs, outside of occupational therapy, specifically designed for fine motor skills. There are exercises elders can do to maintain flexibility and strength in the hands and fingers, but there are few programs people can attend, like Zumba, water aerobics, and yoga, that focus on just the smaller muscle groups. Some smaller exercises that help with hand and wrist mobility would be making and squeezing fists, wrists curls, towel gathering, weight bearing/stretching, and thumb flexion and extension (Flint Rehab, 2018). These help with flexion, extension, supination, and pronation of the wrists and hands, which helps increase mobility and flexion. These exercises, along with the many other exercises that help with the hands, can be modified to increase strength and flexibility overtime to help improve the ability finger-utensil usage.

There are also many functional tasks that can be done that actually help with hand and finger mobility. In occupational therapy sessions, some exercises used for people to regain hand mobility are tasks like pouring from a bottle with a handle, moving clothes pins from one area to another, carrying objects that require a hook grip, screwing or unscrewing lids, digging for objects in sensory items, and placing items in the right spots (Versfeld, 2018). Most of these exercises are functional tasks that are

normally done around the house, but they help regain mobility, strength, and precision of the hands and fingers at the same time. These exercises will help improve grip strength, hand-eye coordination, eye tracking, wrists and finger flexibility, sensory processing, and allows grasping practice. This helps increase overall independence and the ability for an individual to be able to feed themselves using utensils.

In addition, there are exercises available to relieve arthritis pain in the hands and fingers. Finger bends (including the thumb), finger lifts, shaping letters with the hands (C and O), making fists, bending just the end of the middle joints of the fingers to almost make "claws", and practicing spreading the fingers on a flat surface (Mayo Clinic, 2018). These help reduce stiffness and maintain range of motion. Heat therapy can be used for comfort and swelling, as well. Heat helps with stiffness and tired muscles to help increase circulation (Veritas Health, 2018). The reduction in pain and stiffness can help individuals have more range of motion to be able to use utensils to eat.

Some therapy sessions even offer paraffin wax treatments that apply heat to the parts submerged in wax, longer than hot towels would be able to. This treatment requires the paraffin wax and the bath, to warm the wax up in, so people can also purchase it individually and do it at home. However, the price can range depending on the type, quality, and how often it will be used. The warm wax relieves pain and inflammation by increasing blood flow and relaxing the muscles (American Society for Surgery of the Hand, 2015). With a decrease in pain from the arthritis, people will be

more willing to work on exercises that help improve hand mobility to maintain that range of motion. Individuals would have an easier time griping and using their had strength to make using utensils easier to be able to successfully feed themselves, as well.

Along with the current exercises available to help maintain hand mobility, there are also home adaptations and tools now available to make feeding oneself easier. For example, there are adaptive eating utensils designed to help provide compensation for loss of muscle strength and grip, to help individuals have an easier time feeding themselves. Some of the products just have add-on cuffs to make normal utensils have bigger handles or walls, while some are already made with wider handles, wrap around the wrists, cuffs for the hands, or are already slightly slanted to help pick up food. There are also specially designed plates that have sections and high walls, and bowls with suction cup bases that make it easier to scoop the food with the utensils. There are even assistive utensils designed for people with tremors that help make it steadier for people with Parkinson's disease or Dementia.

However, as helpful as these items may be, they can be somewhat expensive. On ProMed Products Express, a physical therapy equipment supplier, a set of one adaptive fork and spoon costs $21.66 for just a pediatric size. A plate with rounded upward sides costs $10.10, while food guards that are just used to clip onto a regular plate, to act as rounded sides, cost $14.95. These prices alone might not sound like a

lot, but when added together over time, it can be expensive and less accessible to a lot of people. Not everyone will be able to afford these products, so there should be other options available to make assistance more accessible to the majority.

Exercise as Medicine

Recently there has been a new global health initiative launched by the American College of Sports Medicine. The initiative focuses on "encouraging primary care physicians and other healthcare providers to include physical activity when designing treatment plans, and to refer patients to evidence-based exercise programs and qualified exercise professionals" (American College of Sports Medicine, 2019). Information is provided online of general guidelines that physicians can use to determine patients' current physical activity levels, willingness to change, and how to prescribe a safe amount of exercise for that specific individual.

Although the initiative's aim is mostly towards primary care physicians or other health care providers, it has given people who are trying to maintain mobility, another resource to use. A lot of the included exercise suggestions are targeted for individuals with conditions that are most commonly seen in the elderly population. There are suggestions for lower back pain, rheumatoid arthritis, osteoarthritis, and osteoporosis, which would all impact an individual's ability to maintain mobility for walking and finger-utensil usage. There are a wealth of information provided for other conditions that are

important to an individual's overall health. These include exercise program suggestions for asthma, cancer, chronic obstructive pulmonary disorder, heart failure, high blood pressure, and weight management.

One example that shows the type of information provided, are the exercise program suggestions for individuals with rheumatoid arthritis. Rheumatoid arthritis can cause pain and stiffness in the joints, mainly the fingers, which can impact an individual's ability to do daily activities like using utensils for self-feeding. The American College of Sports Medicine (2019) suggests low-impact activities that can be done in intervals of ten minutes for three times a day. It also suggests various types of exercise programs that are good for this condition, how people can get started on "personalized" programs, how it can be adapted to an at-home workout, cautions individuals should be aware of, resistance exercises, and other options that have been proven to be beneficial.

Even though this is a very informative resource that definitely can help people work towards maintaining mobility for walking and finger-utensil usage, these handouts were all designed to be used by healthcare providers and professionals. This information could be used by anyone who has access to the internet, however it is formatted for people who are familiar in the field. This can make it more difficult for people, who may not have the same background knowledge, to understand and complete themselves. The information was also not specifically made for elders, even

though there are a lot of constraints and conditions that can be applied to that part of the population. The main intention was to assist primary care physicians with prescribing physical activity in the right amount of "dosages" to help prevent and manage chronic health conditions in clinical practice.

Therefore, there seems to be a gap connecting the DST and the elder population. There are current adaptations and programs available that the theory can be successfully applied to for both walking and finger-utensil usage. Aerobic programs, the health initiative, the adaptive feeding utensils, and occupational/physical therapy sessions have all benefited and helped a lot of elders regain and maintain mobility levels. However, there are very few programs existing that were designed, initially, with the DST in mind and the elder population. The theory is always applied after the program is made, instead of purposefully designing a program that manipulates the most constraints to produce the most advantageous movement outcomes from the beginning.

WHAT IS THE NEED

It was the purpose of this project to link the DST to exercise programs that will help with the maintenance of mobility, specifically for walking and finger-utensil usage for elders. All the existing programs offered today (Zumba, water aerobics, yoga, modified utensils, etc.) are great options that have been seen to be beneficial to the

elderly population. However, this project was intended to help explore how the process would change, and how the results would differ, if the existing programs were modified intentionally with the DST in mind. There are many different factors that affect every individual, making it more beneficial to link a theory that is based on the present constraints to a specific population to see how it can help maintain these two important motor skills.

This topic of mobility is important to discuss and be aware of because everyone ages. People are starting to live longer, and the elderly part of the population is continuing to increase at a high rate. As of 2016, the Population Reference Bureau projected that the number of Americans, ages 65 and older will more than double from 46 million to over 98 million by the year 2060. It was also projected that the part of the population that consists of individuals 65 years and older will rise from 15 percent to 24 percent (Mather, 2016). The demographics of the population has already started to shift, and more people will be going through the physical and psychological changes that occur when entering this stage of life. The effects of muscle and bone loss will be felt, the effects of cartilage degeneration will arise, psychological impairments will start to impact motor functioning, and the risks of developing chronic disabling diseases will increase. This is why it is important to explore new ways to accommodate all these changes, now, before waiting until the population completely shifts.

Along with that, the application of the theory can also help in other aspects of life and even for people who are younger than 65 years of age. The theory can be applied to help people transition into new phases of life. These new phases of life can include: middle aged adults starting to reach age 65, infants becoming toddlers, teenagers becoming adults, or even unexpected life events that force people to have a new lifestyle. The DST can be applied to almost every situation since it is based on the interaction of the present constraints. People could intentionally use the theory as a proactive way to transition themselves further and accommodate the new changes that result from just life itself. If more people knew and understood that they could manipulate their own constraints, to their advantage, more people could possibly have an easier time with the aging process. However, not too many people are aware of the theory and all the benefits it could have when applied intentionally.

In addition, the DST will be important to consider because there are a lot of ways individuals will need intervention with current exercise programs. Whether this be to help maintain mobility or just keep an active lifestyle, there are a lot of different situations that could benefit from a program designed from this theory being applied to the elder population. For example, people who are recovering from a stroke might need physical, occupational, or speech therapy similar to therapy an elder might need, even if the stroke patient is not age 65 or up. Although a vast majority of strokes do occur in people over the age of 65, the likelihood of having a stroke starts to double after age 55 (American Stroke Association, 2018). In 2009, the Centers for Disease Control and Prevention, reported that 34% of people hospitalized for a stroke were actually less than

65 years old. The American Stroke Association (2018) even reported that strokes can occur in babies and children, resulting in the same long-term damages that would occur in an older individual who suffered a stroke.

The effects of a stroke can cause temporary or permanent damage, depending where the stroke occurred and what parts of the brain were affected. Paralysis of one side of the body, vision and speech impairments, memory loss, and loss of motor control can all be affected (American Stroke Association, 2018). This would cause individuals to have a difficult time performing everyday activities like walking and using utensils to feed oneself. An exercise or rehabilitation program, similar to one made specifically for the elder population, might be needed, even to assist individuals younger than age 65 since they might be, physically, at the same performance level.

This is when the DST would become very useful because the rehabilitation program, based off the theory for the elder population, can still be used. It can be altered to fit the individualized constraints of the specific person, though there would already be a framework from which individuals could work. Currently, there are therapy programs designed precisely for people recovering from a stroke or brain injury, however these DST programs can additionally help those who are responsible for taking care of the injured individual. It can provide another resource that could make the information easier to understand, so that the exercises are easier to accomplish.

Therefore, there will always be a need to have a program designed with the DST in mind, not just for the elder part of the population, but for anyone to proactively transition into new stages of life. As a large segment of our population starts to become

older and feel the changes that occur when entering this part of life, it is important that we consider new ways to adapt to that. Simultaneously, it would give more options to those who feel the effects of muscle and bone loss, cartilage degeneration, sensory impairments, and chronic diseases all before reaching 65 years old. It is important to explore new ways of maintaining mobility now, before the elder population increases dramatically. It is vital to find ways that bridge the gap and help accommodate the elderly's maintenance of mobility to ensure the functioning flow of society, as the demographics continue to shift towards more elders and less working class.

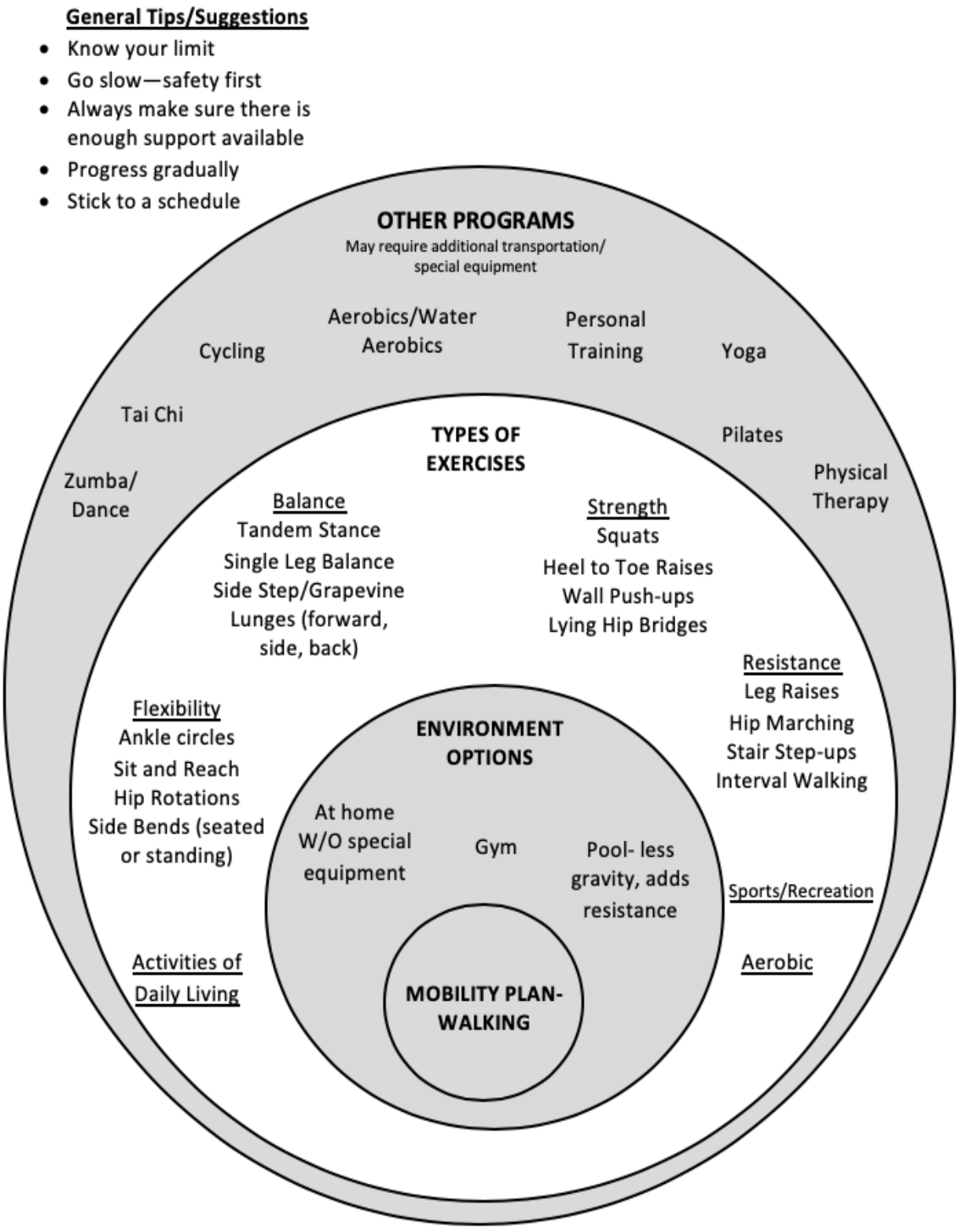


Figure 4: Walking Mobility Plan

Flexibility Exercises

1. Ankle Circles—can be sitting or lying
    - Increases ankle mobility to help improve dorsiflexion while walking
    - Strengthens the abdominals, thigh, and calf muscles
    - Can be done at home, in the gym, or in the pool

Table 1: Ankle Circle Instructions

Internal Focus Instruction	External Focus Instructions
● Sit or lie down on one side (sitting gives more stability) ● Point toes upwards and slowly rotate the foot in circles both clockwise and counterclockwise ● 3 sets of 10 circles	● Sit or lie down on one side (sitting gives more stability) ● Point shoes upwards towards the ceiling and rotate the shoes to make circles in clockwise and counterclockwise directions ● 3 sets of 10 circles

- Modifications:
    - Ankle weights
    - Perform standing up
    - Do in the pool to increase resistance

2. Sit and Reach
    - Increases flexibility in the hamstrings, lower back, and glutes
    - Increases range of motion
    - Can be done at home with no equipment

Table 2: Sit and Reach Instructions

Internal Focus Instruction	External Focus Instructions
● Sit on a flat surface ● Slowly grab your toes with the tip of your fingers by extending both arms in front ● Go as far as you can ● Hold for 10 seconds, release, and start again	● Sit on flat surface ● Slowly reach for your shoes to grab the tips ● Go as far as you can ● Hold for 10 seconds, release, and start again

3. Hip Rotations
    - Increases range of motion
    - Stretches the hip flexors, abdominals, and lower back

Table 3: Hip Rotation Instructions

Internal Focus Instruction	External Focus Instructions
● Stand up straight with your abdomen tightened, feet shoulder-width apart,	● Stand up straight, look forward at an object straight in front of you, and

and shoulders back. Or sit up straight in a chair with same upper body instructions ● Rotate torso one direction as far back as you can, or close to 90-degree angle, for 5 seconds ● Go back to center and repeat on other side ● Complete 5-10 twists on each side	adjust shoes to shoulder width apart. Or sit in a chair and look forward with proper posture ● Look backwards one way at something behind you and hold that position for 5 seconds ● Return to starting position and repeat on opposite side by still trying to look at the same object behind you ● Complete 5-10 twists on each side

- Modifications
    - Can add weights
    - Be in a lunge position while completing the exercise

4. <u>Side Bends</u> -sitting or standing
    - Stretches the abdominals and obliques
    - Improves posture and stability
    - Increases flexibility of the lower back
    - Can be done anywhere

Table 4: Side Bend Instructions

Internal Focus Instruction	External Focus Instructions
● Stand up straight with tightened abdomen, looking straight ahead, shoulders back, and feet shoulder-width apart ● Place one hand behind your head and the other arm stretched downwards to one side ● Lean over to one side ● Hold for 5 seconds, return to center, and repeat for opposite side ● Repeat 5-10 times on each side	● Keep shoes flat on surface, about shoulder-width apart, look straight forward ● put one hand behind your head and the other arm downwards on the side ● Slowly reach for the floor with the arm on the side. Go as much as you can without falling over, hold for 5 seconds, return to center, and repeat on other side ● Repeat 5-10 times on each side

- Modifications
    - Hold weights
    - Lying side bends- lie flat on back with knees up like you are going to sit-ups and reach for one heel and then the other

Balance Exercises

1. Tandem Stance
    - Improves equal weight bearing stance to increase balance
    - Can be done anywhere

Table 5: Tandem Stance Instructions

Internal Focus Instruction	External Focus Instructions
● Place one foot directly in front of the other like in a heel to toe position ● Engage the core and balance for 10-30 seconds, rest, and repeat ● Switch which foot is in front ● Make sure support is nearby	● Place one shoe directly in front of the other so that the tip of one show is touching the heel of the other shoe ● Pretend you are on a tightrope and balance for 10-30 seconds ● Rest, repeat, and switch which shoe is in front

- Modifications:
    - Can stagger stance to make it easier
    - Close eyes while balancing to make it more difficult
    - Can start to walk heel to toe

2. Single Leg Balance
    - Improves balance in one leg, which is needed to walk
    - Can be done anywhere

Table 6: Single Leg Balance Instructions

Internal Focus Instruction	External Focus Instructions
● Stand upright with feet together ● Can use a chair or any supportive devices if needed ● Raise one leg forward off the floor with knee bent. Bring knee towards the chest until it is about hip height ● Hold stance for 10 seconds, rest, and repeat on other side	● Stand upright with shoes together ● Can use a chair or any supportive devices if needed ● bring knee closer to your shirt, but not more than a 90-degree angle ● hold stance for 10 seconds, rest, and repeat on the other side

- Modifications:
    - Close your eyes
    - Don’t use any surfaces to help with balance, but be around support just in case
    - Stand on a pillow, foam pad, bosu ball
    - Can add ankle weights to also help increase strength
    - Can pulldown on cable cord when

3. Side Step/Grapevine
    - Practices weight shifting to improve walking strides

- Helps lengthen strides
- Works on agility and eye tracking
- Can be done anywhere (pool might be a good place to start if balance is poor)

Table 7: Side Step Instructions

Internal Focus Instruction	External Focus Instructions
● can start by stepping side-to-side until comfortable ● start grapevine exercise by standing up straight with hands on the hips ● lift heel off the floor and prepare to step sideways ● Follow pattern of left step to the left, right step behind the left, left step again to the left, and then right step to bring feet together	● can start by stepping side-to-side until comfortable ● start grapevine exercise by standing upright and place hands by the top of your pants pockets. If no pockets, just imagine where it would be ● prepare to step sideways ● Follow pattern of left step to the left, right step behind the left, left step again to the left, and then right step to bring the shoes back together

- Modifications:
  - Extend distance
  - Increase pace

4. <u>Lunges</u>
   - Strengthens the quadriceps and hips
   - Works on balance and unilateral leg function
   - Can be done anywhere

Table 8: Lunges Instructions

Internal Focus Instruction	External Focus Instructions
● Keep upper body straight with shoulders back ● Step forward with one leg, lower hips until knees are bent to about a 90-degree angle, or as far as you can until 90-degrees ● Make sure the knee is above the ankles and that the knee is not touching the floor ● Hold for 10-30 seconds, repeat, and change feet	● Stand upright and look at something right in front of you ● Take one step forward with one side to be in a staggered stance position ● Slowly lower body towards the ground until a 90-degree angle, or as far as you can until then ● Make sure nothing but your shoes are touching the ground and that you can see the tips of your shoes when bending ● Hold for 10-30 seconds, repeat, and change feet

- Modifications

- Can lunge backwards, side wards, or walking lunges with theraband
- Can hold small weights
- Can lunge, hold for a couple seconds, return to standing position, and repeat again 10 times before switching feet

Strength Exercises

1. Squats (to chair)
    - Strengthens quadricep, hip muscles, and abdominals
    - Improves ability to get up from chair to walk
    - Works on balance and coordination
    - Can be done anywhere

Table 9: Squat Instructions

Internal Focus Instruction	External Focus Instructions
● Stand with feet at a comfortable width with both feet pointing in the same direction ● Keep face forward, chest up, heels on the ground ● Slowly lower yourself as much as you can by pushing hips back and bending at the knees ● Can squat over a chair for extra stability and safety ● Return to standing position and repeat 10 times	● Stand with shoes at a comfortable width apart, with both tips pointing forwards ● Look at something in front of you and pretend to put shoulder blades in back pocket ● Slowly squat and pretend like you are going to sit in a chair. Can have chair there for extra stability and support ● Return to beginning position and repeat 10 times

- Modifications
    - Can start by sitting in a chair, lift yourself off a few inches, and then lower back into the chair
    - Perform more repetitions and add weights
    - Can squat and throw objects to another person or to the wall

2. Heel to Toe Raises (standing)
    - Improves strength in calves and toes for walking
    - Improves balance
    - Can be done anywhere

Table 10: Heel to Toe Raise Instructions

Internal Focus Instruction	External Focus Instructions
● Use counter, wall or support ● Lift toes off the floor and keep heels on floor with knees straight ● Hold for about 5 seconds and then return toes to floor ● Lift heels off the floor while keeping toes on the floor with knees straight ● Repeat 5 times per leg	● Use counter, wall, or support ● Raise the tips of your shoes up towards the ceiling and keeping back part of shoe on the ground ● Hold for 5 seconds and return to starting position ● Lift the back part of your shoes towards the ceiling and balance on the tips of your shoes ● Repeat 5 times per leg

- Modifications
    - Do one leg at a time to work more on strength and balance
    - Can be done sitting
    - Can do walking toe raises or walking heel raises

3. Wall Push-ups
    - Strengthens arms, shoulders, and chest area to provide more stability when walking

Table 11: Wall Push-up Instructions

Internal Focus Instruction	External Focus Instructions
● Face wall, feet shoulder-width apart ● Lean body forward and place palms on the wall at around shoulder height ● Slowly bend elbows and lower yourself towards the wall and keep shoes on the floor ● Hold for a second and then slowly return to starting position ● Repeat 10-15 times	● Face wall and make stance so that shoes are aligned with the sleeves of your shirt ● Lean straight forward and touch the wall with your hands ● Slowly bring yourself closer to the wall so that your shirt gets as close as it can ● After going as far as you can, hold for a second and slowly return to starting position ● Repeat 10-15 times

- Modifications
    - Can do one arm wall push-ups
    - Can slowly start doing incline push-ups or knee push-ups

4. Lying Hip bridges
    - Engages glutes and helps open the hips for more flexibility and range of motion when taking strides
    - Strengthens lower back and hamstrings
    - Can be done in gym or at home

Table 12: Lying Hip bridge Instructions

Internal Focus Instruction	External Focus Instructions

● Lie flat on your back ● Bend knees and place feet about hip-distance apart with heels a few inches apart. Keep feet flat on surface ● Push hips upwards while squeezing the glutes. Your knees, hips, and shoulders should form a straight line ● Keep arms flat on surface, palms facing down ● Hold for 1-2 seconds and slowly lower back down ● 3 sets of 10	● Lie down flat so that you are facing the roof ● Bend knees and line shoes up to width of hips, so that the heels of your shoes are only a few inches apart. Keep shoes or socks flat on surface ● Slightly raise your pants towards the roof, bringing the button of your pants upwards ● Keep your t-shirt sleeves flat on the surface ● Hold for 1-2 seconds when raised and slowly lower back down until flat again ● 3 sets of 10

- Modifications:
  - Single-leg hip bridge
  - Add more repetitions
  - Use resistance band and place right above the knees
  - Weighted glute bridges- place weight over hips to strengthen glutes more

Resistance Exercises

1. Straight Leg Raises (Forward, back, and side)
    - Strengthens core to improve muscle endurance and decrease strain on supporting muscles from bad posture
    - Strengthens leg muscles and hip flexors
    - Works on balance
    - Can be done anywhere

Table 13: Straight Leg Raise Instructions

Internal Focus Instruction	External Focus Instructions
● Can use a chair or counter for extra support and balance ● Keep back straight and lift one leg upwards without bending the knees ● Stop before or when hip level is reached ● Hold for one second and slowly lower back down ● Repeat 10-15 times, then switch legs ● Go forward, backwards, and sideward	● Can use a chair or counter for extra support and balance ● Stand tall and lift one shoe upward by bringing the tips of the shoe towards the ceiling without bending the knees ● Stop when the tips of the shoes are around the same height as the waist. ● Hold for one second and slowly lower back down ● Repeat 10-15 times, then switch legs ● Go forwards, backwards, and sideward

    - Modifications:
        - Ankle weights can be added
        - Can be done lying down flat
        - Can be done in pool to help with balance and add resistance
        - Increase number of repetitions
        - Add resistance bands

2. Hip Marching
    - Strengthens hip flexors and thighs
    - If seated, it can help abdominal muscles
    - Can be done anywhere

Table 14: Hip Marching Instructions

Internal Focus Instruction	External Focus Instructions
● Stand straight, tighten the abdominals ● Bend and lift one knee as high as you can or until hip level while maintaining balance	● Stand upright ● Pretend to juggle a ball in the air with one thigh by bending the knees and slowly bringing it to waist level. Remember to maintain balance.

● Hold for one second, lower it back down, and lift opposite knee ● Repeat 20 times (10 per leg)	● Hold for one second, lower back down, and lift opposite side ● Repeat 20 times (10 per leg)

- Modifications
    - Can be done sitting
    - Hold raised leg for a couple of seconds before lowering
    - Add ankle weights
    - Increase repetitions

3. Forward Stair Step-ups
    - Works on strengthening and toning leg muscles
    - Gets blood flow moving
    - Balance and stability
    - Can be done anywhere

Table 15: Stair Step Instructions

Internal Focus Instruction	External Focus Instructions
● Step up with one foot, then the other, step down with the first foot, and then down with the other ● Repeat 10-15 times and switch which foot goes first	● Stand at the bottom of a staircase or platform ● Bring one shoe on top, then bring the other shoe, bring first shoe back to floor behind you, and repeat with the other ● Repeat 10-15 times and switch which shoe goes first

- Modifications:
    - Can use railing or nearby counter
    - Can do side and backward steps
    - Can do toe taps instead or with exercise
    - Weights can be added
    - Raise knee to hip level in between steps for more difficulty

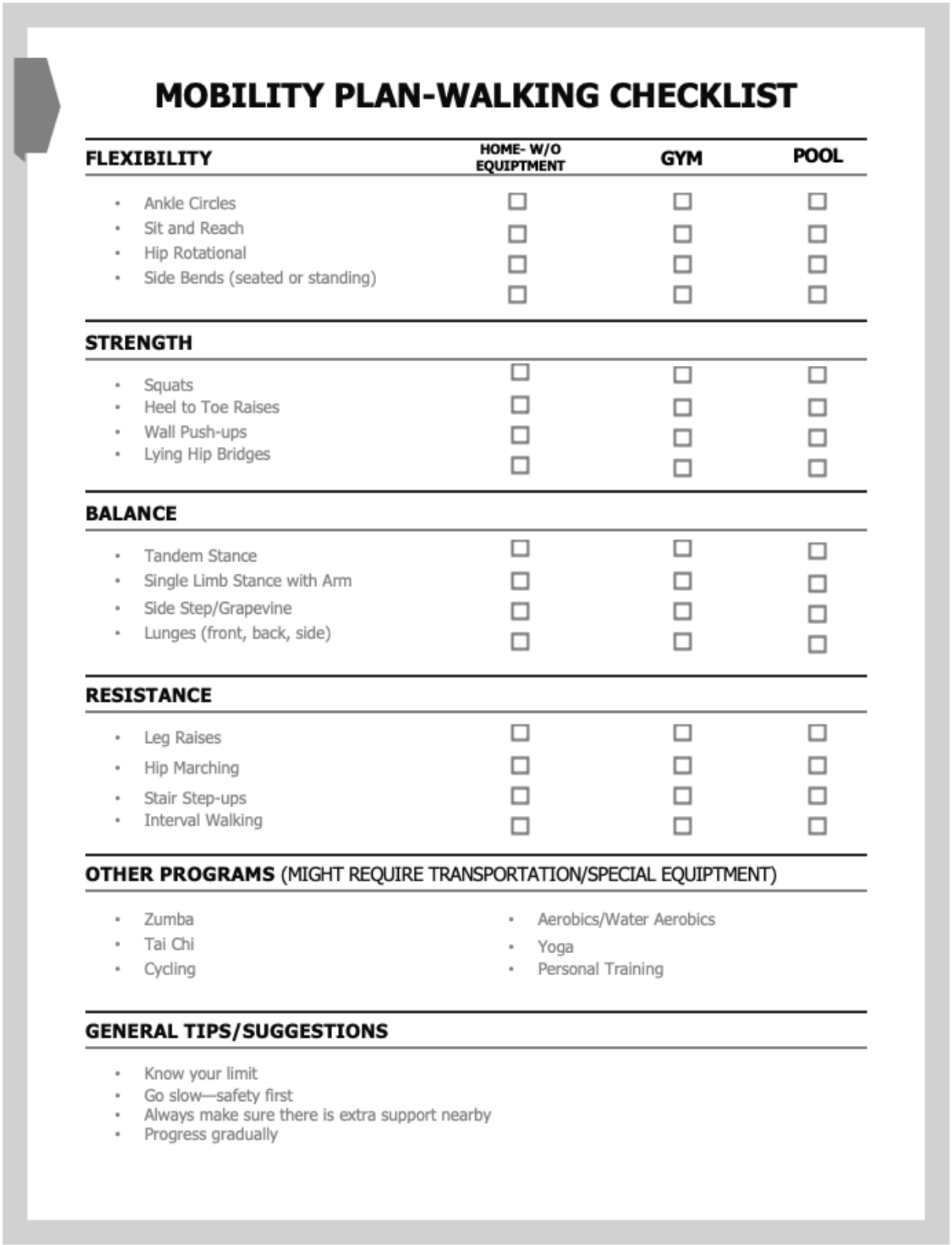
4. <u>Interval Walking</u>
    - Good aerobic exercise
    - Can be done outside, on a treadmill, or in the pool

Table 16: Interval Walking Instructions

Internal Focus Instruction	External Focus Instructions

● Start with a warm up by walking at a normal pace. Focus on equal steps and weight-shifting on the hips ● Start to walk at a brisk level for 1-3 minutes, walk at a moderate pace for 2-4 minutes, walk slowly, and then repeat.	● Start with a warm up by walking at a normal pace. ● Start to walk at a brisk level for 1-3 minutes, walk at a moderate pace for 2-4 minutes, walk slowly, and then repeat. ● Gauge what you can handle

- Modifications:
    - Extend/Minimize duration and distance
    - Adjust intensity levels and add incline



MOBILITY PLAN-WALKING CHECKLIST

FLEXIBILITY	HOME- W/O EQUIPTMENT	GYM	POOL
• Ankle Circles	☐	☐	☐
• Sit and Reach	☐	☐	☐
• Hip Rotational	☐	☐	☐
• Side Bends (seated or standing)	☐	☐	☐

STRENGTH			
• Squats	☐	☐	☐
• Heel to Toe Raises	☐	☐	☐
• Wall Push-ups	☐	☐	☐
• Lying Hip Bridges	☐	☐	☐

BALANCE			
• Tandem Stance	☐	☐	☐
• Single Limb Stance with Arm	☐	☐	☐
• Side Step/Grapevine	☐	☐	☐
• Lunges (front, back, side)	☐	☐	☐

RESISTANCE			
• Leg Raises	☐	☐	☐
• Hip Marching	☐	☐	☐
• Stair Step-ups	☐	☐	☐
• Interval Walking	☐	☐	☐

OTHER PROGRAMS (MIGHT REQUIRE TRANSPORTATION/SPECIAL EQUIPTMENT)

- Zumba
- Tai Chi
- Cycling
- Aerobics/Water Aerobics
- Yoga
- Personal Training

GENERAL TIPS/SUGGESTIONS

- Know your limit
- Go slow—safety first
- Always make sure there is extra support nearby
- Progress gradually

Figure 5: Walking Mobility Plan Checklist

Finger Utensil Usage Mobility Plan

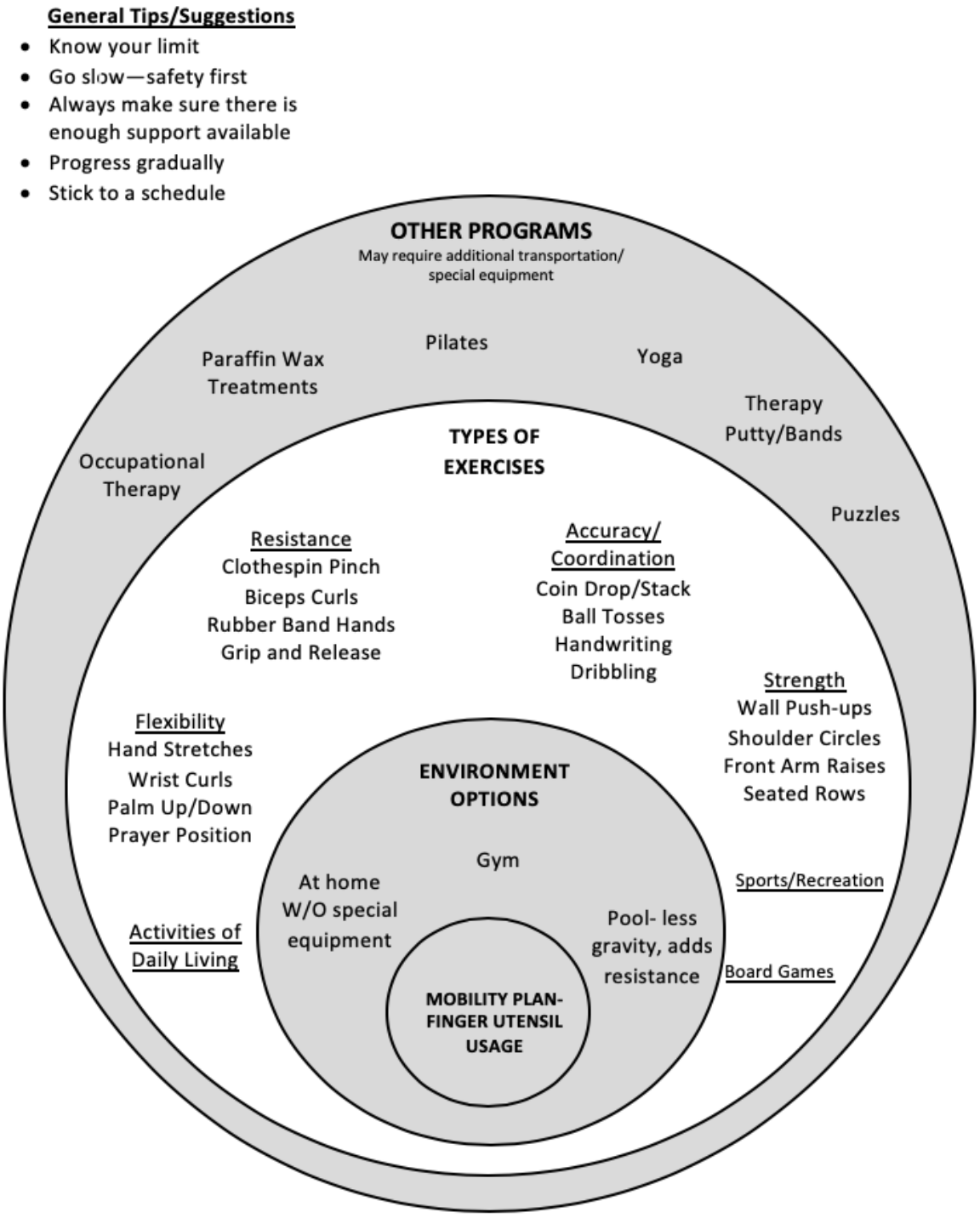


Figure 6: Finger-Utensil Usage Mobility Plan

Flexibility Exercises

1. Hand Stretches
    - Increases range of motion in the fingers and helps stretch them
    - Can be done anywhere
    - Options:
        - Practice alphabet for American sign language
        - Finger Stretches: place hand palm-down on table, straighten fingers as flat as you can, hold for 30-60 seconds, release,
            - Repeat 5-10 times per hand
        - Claw Stretch: hold hand out in front of you, bend fingertips down to touch the base of each finger joint, hold for 30-60 seconds, and release
            - Repeat 5-10 times per hand
        - Finger Lifts: place hand flat on surface, palm down, and gently lift one finger until you can't anymore, and then lower back down
            - Do all fingers
            - Repeat 5-10 times per finger
        - Finger Curls: practice touching your thumb to each of your fingertips, starting with index finger and moving down towards the pinky
            - Repeat 5-10 times
        - Thumb Flex: hold hand in front of you, palm up, extend thumb away from fingers as far as you can, bend thumb across the palm to touch the pinky
            - Hold for 30-60 seconds, repeat 5-10 times each thumb
    - Modifications:
        - Can use Thera Bands for extra resistance

2. Wrist Curls
    - Can be done anywhere
    - Increases range of motion in the wrists and works on grip

Table 17: Wrist Curl Instructions

Internal Focus Instruction	External Focus Instructions
● Rest forearm on the arm of a flat surface and hang hand over the edge ● Slowly bend wrist up and down as much as you can ● Repeat 10-15 times each wrist	● Lean weight over the edge of a flat surface and have it facing upwards so that the inside of your sleeve is also pointing upwards ● Slowly raise and lower weight up and down, towards the ceiling and floor, as much as you can before dropping it ● Repeat 10-15 times each wrist

    - Modifications:

- Use heavier or lighter weights, cable cords, or bands (can even use household items like a water bottle)
- Increase repetitions
- Reverse curls- just facepalm down and flex wrist upwards
- Behind the back-wrist curls

3. Palm Up/Down
    - Can be done anywhere
    - Increases range of motion in the whole hand and fingers

Table 18: Palm Up/Down Instructions

Internal Focus Instruction	External Focus Instructions
● Place hand on flat surface with palms facing up ● Use non-affected hand to help flip palm down ● Repeat back and forth, 10 times total	● Place hand on flat surface with the inside of sleeve facing upwards ● Use non-affected side to push down and make sure skin and surface is touching while flipping back and forth on table ● Repeat back and forth, 10 times total

- Modifications:
    - Increase repetitions
    - Include side movements by moving hands laterally, side to side, while keep wrists stable

4. Prayer Position
    - Focuses on range of motion in fingers and wrists
    - Helps with shoulder movement

Table 19: Prayer Position Instructions

Internal Focus Instruction	External Focus Instructions
● Start with palms together and elbows slightly bent ● Lower the sides of the hands towards the table until you feel a stretch, but keeps palms together ● Hold for 5-10 seconds ● Relax and repeat 3 times	● Start with prayer hand positioning and lower to a flat surface ● Slowly try to bring the sleeves of your shirt outwards, but keep prayer position intact and on the flat surface ● Hold for 5-10 seconds ● Relax and repeat 3 times

- Modifications:
    - Reverse prayer position- goes behind the back
        - Can also try doing it with just one hand at a time

Resistance Exercises

1. Clothespin Pinch
    - Can do it with or without clothespins
    - Works on finger strength and endurance for finger-utensil usage
    - Works on grip strength

Table 20: Clothespin Pinch Instructions

Internal Focus Instruction	External Focus Instructions
● Using standard clothespins, use the thumb and first finger to pinch the clothespin ● Hold open for 5-10 seconds ● Relax and repeat 10 times for each hand	● Using standard clothespins, pinch the clothespin open ● Hold open and make sure the two end pieces you are pinching are touching one another for 5-10 seconds ● Relax and repeat 10 times for each hand

- Modifications:
    - Practice moving clothespins from one spot to another
    - Perform with tweezers, tongs, or putty
    - Use clothespins to pick up smaller objects

2. Biceps Curls
    - Works on arm strength and grip strength
    - Works on muscular endurance

Table 21: Bicep Curls Instructions

Internal Focus Instruction	External Focus Instructions
● Stand tall with feet around hip-width apart ● Hold a weight with each hand with arms at your sides and palms facing forward ● Keep torso stationary and elbows tucked close to your side, bend your elbows and flex upwards ● Pause and then return to starting position ● 3 sets of 12-15 reps	● Stand upright with shoes facing forward and about hip-width apart ● Hold a weight on each side and start with weights down along your sides ● Slowly bring weights upwards towards the ceiling and remember not to let your arm go out like a chicken wing. Pretend to be holding a piece of paper in between the arms and body ● Pause when weights have come up all the way and return to starting position ● 3 sets of 12-15 reps

- Modifications:
    - Increase the weight and repetitions
        - Can be done without a weight, just make your hands into fists
    - Can use bands or cable cords instead of weights

- Start with elbow and forearm on flat surface instead of down at the waist

3. Rubber Band Hands
   - Strengthens finger flexion and extension
   - Improves muscle strength and endurance

Table 22: Rubber Band Exercise Instructions

Internal Focus Instruction	External Focus Instructions
● Place a rubber band around your thumb and fingers so that it runs through the middle of your thumb ● Slowly try to extend all fingers away from each other ● Hold for 20-30 seconds, relax, and repeat 10-15 times	● Place a rubber band around the fingers and thumb, so that it runs through the middle of your thumb ● Try to stretch the rubber band out as far as you can ● Hold for 20-30 seconds, relax, and repeat 10-15 times

- Modifications:
  - Can do other hand stretches mentioned above while having rubber band wrapped around the fingers
  - Can increase the amount of rubber bands or thickness
  - Increase the amount of repetitions

4. Grip and Release
   - Can be done with any object
   - Works on finger grip and strength
   - Instructions:
     - Make a fist with thumb wrapping around fingers, hold for 30-60 seconds, and open hands up again to spread fingers out as much as you can
       - Repeat 5-10 times each hand
   - Modifications:
     - Can squeeze Thera Bands, putty, small stress balls, or any hand grip strengthener tools
     - Increase repetitions throughout the day

Accuracy/ Coordination Exercises

1. Coin Drop/ Stack
    - Works on hand-eye coordination
    - Works on hand control

Table 23: Coin Drop Instructions

Internal Focus Instruction	External Focus Instructions
● Place coins in a row across your palm ● Practice placing them down one by one onto another surface while keeping other coins in your hand with your other fingers ● Once all coins are transferred, pick them up and place them along palms ● Repeat	● Place coins in a row across the palm ● Slowly lower each one onto another surface while keeping the other coins still and where they are at ● Once all coins are transferred, pick them up, and place them back where it started ● Repeat

- Modifications:
    - Practice stacking them on top of one another like a tower
    - Use different size coins to make it easier or more difficult (can use any object that fits in your hands)

2. Ball Tosses
    - Works on hand-eye coordination and accuracy
    - Improves range of motion in the arms, increases endurance and balance
    - Works on grip and reaction time
    - Can be done using a wall or with a partner

Table 24: Ball Tosses Instructions

Internal Focus Instruction	External Focus Instructions
● Face the target ● Use the foot opposite to the hand you will use to throw the ball and take one step forward ● Use a pendulum arm motions to toss underhand, starting from behind you ● Continue the motion and release the ball between the waist and knee level ● Follow through with the arm to hit your target ● Catch ball when it comes back ● Repeat using opposite arm	● Place a target on the wall or use your partner as your target ● Face the target, take one step towards the target with the opposite foot, and toss a tennis ball with one hand to hit the target ● Make sure you use enough force for it to get there (and back if using a wall) ● Focus on increasing the arch of the ball if trying to hit targets further away ● Catch the ball when it gets back to use

	● Repeat and using opposite side

- Modifications:
    - Increase/decrease the distance away
    - Use different sized balls or objects (different shapes, weights, lengths, textures)
    - Have partner throw balls some of the balls to the side of you, slightly overhead, or slightly lower so it is not always coming directly into your hands. If using a wall, practice throwing it at different angles to get the same results.
    - Use several balls at once or try to juggle
    - Walk and toss

3. Handwriting Practice
    - Practices grasp and finger strength
    - Works on accuracy, control, and coordination
    - Helps with cognition
    - Instructions:
        - Practice writing words/alphabets/numbers in regular writing or cursive using a pencil or pen
        - Practice drawing/painting shapes or anything you want to draw

    - Modifications:
        - Can use thicker markers if it is too hard to grasp a pencil at first
        - Can use thinner pens and pencils to make it more difficult
        - Trace certain words/shapes to practice more control and accuracy
        - Practice spinning pen on table using fingers

4. Dribbling
    - Works on hand-eye coordination and control
    - Works on finger strength and range of motion
    - Can be done at home, in the gym, or even in the pool with any flotation device/ball

Table 25: Dribbling Instructions

Internal Focus Instruction	External Focus Instructions

● Spread fingers apart and use fingertips to bounce a ball up and down making sure the ball stays in between the knee and hip for more control ● Make sure to keep your hand on top of the ball ● Practice looking up while bouncing the ball up and down	● Spread fingers apart and use fingertips to push a ball into the floor, making sure there is enough force for it to get back to the top height of your pants. Keep the ball lower to increase control ● Watch where the ball hits the floor and try to keep it in front of you so that it does not hit your shoes but is not too far that you can't reach ● Practice looking at a target in front of you while bouncing the ball up and down

- Modifications:
  - Practice going in different directions with one hand or go around obstacles
  - Use a smaller ball or more than one, increase the pace

Strength Exercises

1. Wall Push-ups
    - Strengthens arms, shoulders, and chest area to help when lifting or lowering utensils to mouth
    - Increases muscular endurance

Table 26: Wall Push-up Instructions

Internal Focus Instruction	External Focus Instructions
● Face wall, feet shoulder-width apart ● Lean body forward and place palms on the wall at around shoulder height ● Slowly bend elbows and lower yourself towards the wall and keep shoes on the floor ● Hold for a second and then slowly return to starting position ● Repeat 10-15 times	● Face wall and make stance so that shoes are aligned with the sleeves of your shirt ● Lean straight forward and touch the wall with your hands ● Slowly bring yourself closer to the wall so that your shirt gets as close as it can ● After going as far as you can, hold for a second and slowly return to starting position ● Repeat 10-15 times

    - Modifications
        - Can do one arm wall push-ups
        - Can slowly start doing incline push-ups or knee push-ups

2. Shoulder Circles
    - Increases range of motion and flexibility
    - Increases circulation in the arm, fingers, and shoulders
    - Increases strength of shoulder muscles, trapezius, deltoid, and rhomboid muscles

Table 27: Shoulder Circle Instructions

Internal Focus Instruction	External Focus Instructions
● Begin standing or sitting and let arms dangle on the sides ● In a large circular motion, forwardly push shoulders out, then up, then back, then down. If preferred, you can hold arms out to the side of you so that they are perpendicular to the torso, and practice rotating in the forward direction ● Repeat motion in other direction by reversing directions	● Begin standing or sitting and let arms down to the sides ● make shoulders rotate in large circular motions going forward. If preferred, you can hold arms out so that they are parallel to the floor, and practice making circles with your arms going in forward direction. ● repeat motion going backwards ● repeat 15 times forward and 15 times backwards

● Repeat 15 times forward and 15 times backwards	

- Modifications:
    - Perform exercises while carrying weights in your hands
    - Arm circles- bring arms to shoulder height to the sides of you to make a T shape. Rotate arms forward and backwards

3. Front Arm Raises
    - Practices flexion and extension in the arms for increased range of motion
    - Works on control and balance in the arms

Table 28: Front Arm Raise Instructions

Internal Focus Instruction	External Focus Instructions
● Begin seated or standing ● Hold a ball in both hands with palms facing each other (can start without ball if needed) ● Slowly raise arms to about shoulder height with elbows slightly bent ● Lower back down ● Take about 3 seconds to raise and lower, repeat 10-15 times	● Begin seated or standing ● Hold a ball out in front of you with palms touching each side of the ball (can start without a ball if needed) ● Slowly raise the ball to a height that you can stare at it right in front of you without having to look up or down ● Lower back down ● Take about 3 seconds to raise and lower, repeat 10-15 times

- Modifications:
    - Increase the weight of the ball, stopping height, and/or repetitions
    - Increase the amount of repetitions
    - Raise on arm at a time. Use a different object or weight so that it can be held in one hand

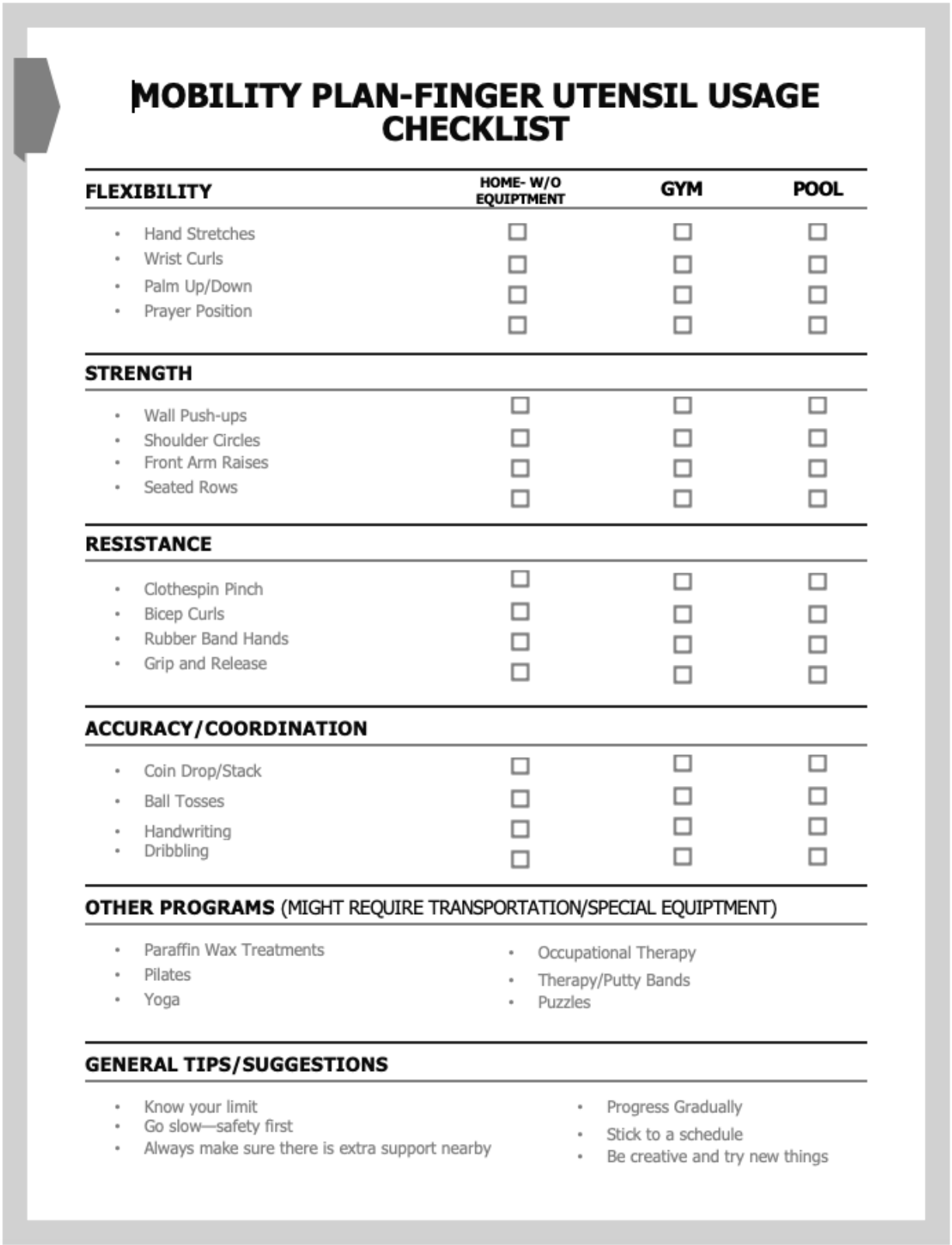
4. Seated Rows
    - Strengthens the back muscles to help with posture and core while sitting up to eat
    - Strengthens the forearm, upper arm muscles, biceps, and triceps
    - Works on muscle control

Table 29: Seated Row Instructions

Internal Focus Instruction	External Focus Instructions
● Start by sitting on a flat surface with legs extended out in front of you and back straight ● Tie a resistance band around your feet	● Start by sitting on a flat surface with shoes out in front of you and the tips pointing upwards. ● Tie a resistance band around your feet

● Grab the ends of the bands by extending arms forward. Keep palms facing each other ● Pull the bands straight back until your hands reach the side of your ribs and make sure you are squeezing your shoulder blades together ● Hold for 1-3 seconds, then slowly extend arms to return to starting position ● Three sets of 10-15 reps	● Grab the ends of the bands with both hands and pull the bands straight back until the tips can touch the side of your shirt ● Squeeze the shoulder blades together by trying to bring the two t-shirt sleeves towards each other ● Hold for 1-3 seconds, then slowly extend arms to return to starting position ● Three sets of 10-15 reps

- Modifications:
    - Use tighter resistance bands or none at all
    - Use cable cords at the gym and increase/decrease the weight
    - Preform in the standing position with knees slightly bent to also work the core muscles



MOBILITY PLAN-FINGER UTENSIL USAGE CHECKLIST

FLEXIBILITY	HOME- W/O EQUIPTMENT	GYM	POOL
• Hand Stretches	☐	☐	☐
• Wrist Curls	☐	☐	☐
• Palm Up/Down	☐	☐	☐
• Prayer Position	☐	☐	☐
STRENGTH			
• Wall Push-ups	☐	☐	☐
• Shoulder Circles	☐	☐	☐
• Front Arm Raises	☐	☐	☐
• Seated Rows	☐	☐	☐
RESISTANCE			
• Clothespin Pinch	☐	☐	☐
• Bicep Curls	☐	☐	☐
• Rubber Band Hands	☐	☐	☐
• Grip and Release	☐	☐	☐
ACCURACY/COORDINATION			
• Coin Drop/Stack	☐	☐	☐
• Ball Tosses	☐	☐	☐
• Handwriting	☐	☐	☐
• Dribbling	☐	☐	☐

OTHER PROGRAMS (MIGHT REQUIRE TRANSPORTATION/SPECIAL EQUIPTMENT)

- Paraffin Wax Treatments
- Pilates
- Yoga
- Occupational Therapy
- Therapy/Putty Bands
- Puzzles

GENERAL TIPS/SUGGESTIONS

- Know your limit
- Go slow—safety first
- Always make sure there is extra support nearby
- Progress Gradually
- Stick to a schedule
- Be creative and try new things

Figure 7: Finger Utensil Usage Mobility Plan Checklist

Concluding Remarks

Using the DST as a template for mobility plans can be beneficial, especially for specific groups that experience changing constraints, like the elder population. The DST allows any plan to constantly go back and forth between the individual, environmental, and task constraints. If one part of an exercise or mobility plan is not working, it can be modified through individual constraints that include where an individual is currently at and what progress they want to make; environmental constraints like performing in the pool or gym; or task constraints that can be modified to make exercises easier or more challenging.

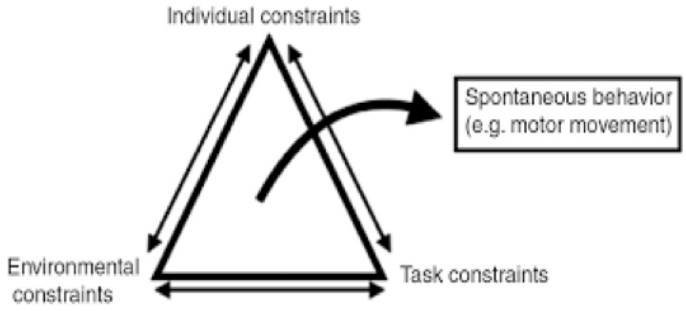


Figure 8: Constraint Interactions

Colombo-Dougovito, A. M. (2016).

The mobility plans were written with internal focus and external focus-based instructions available because sometimes a mix between the two can be just as beneficial. Walking and finger-utensil usage are two skills that people are normally familiar with, so according to Wulf's research, external focus-based feedback should provide the best results. However, as people age, old skills have to be relearned. People might use the external-based instruction for the majority of the exercise, but still

occasionally need internal focused-based feedback as a reminder to what they are specifically supposed to be doing.

Also, it is important to note that external-focus based feedback and the DST mainly focus on providing the most efficient movement for the body. This is usually a beneficial component; however, it is important for individuals to remember the proper technique that comes from using internal-based feedback. Even though a new way of doing something might be more efficient, it does not always mean it is the best technique for the body long-term.

Overall, this project initial steps of creating mobility plans for a specific part of the population, while keeping the DST in mind. There are many more options for exercises, modifications, and creative examples that could be used outside of what was included in these recommended mobility plans for walking and finger-utensil usage. The main goal for these plans was to serve as a template for individuals to start from and build upon. It is hoped that creating these movement plans can give elders more options to enhance their motor performance levels, or even give younger people an idea of a new personalized way to transition into the next stage in life. It is hoped that more awareness on the DST has been created through this project and that more people can understand and start to apply it to any aspect of their life.

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